

Shaping an Integrating Kitchen Space with Gesture-Based Control System

Agata Bonenberg

Faculty of Architecture, Poznan University of Technology,
Nieszawska 13 C, 60-021 Poznan, Poland
agata.bonenberg@put.poznan.pl

Abstract. This article provides a summary of research into the integrating kitchen design: a kitchen designed for simultaneous use by people with mobility problems, including wheelchair bound persons as well as able-bodied people. By introducing mobile gesture controlled modules into kitchen furniture it is possible to dynamically adjust furniture for use in seating or standing positions. An important aspect of research problem is such location of elements which would optimize the simultaneous use of kitchen by two persons: able-bodied and disabled.

Keywords: Integrating kitchen, gesture control system, accessibility, degree of integration, spatial conflict, disabilities.

1 Introduction

This article is devoted to issues related with the integrating kitchen design: a kitchen designed for a simultaneous use by people with mobility problems, including wheelchair bound persons as well as able-bodied people. Ability to dynamically adjust elements of kitchen furnishings to the requirements of all space users (able-bodied and disabled) is a condition which determines whether common activities and everyday interactions will be undertaken – behaviours that are crucial in post-traumatic therapy, therapy for people with disabilities, and prolonging the independence of the elderly. An important aspect of this problem is the ability to use an electric drive to support mobility of structure elements and gesture-based remote control for moving individual furniture modules. This results in a digitally expanded spatial environment which supports its user.

The article focuses on spatial and compositional solutions which result from the use of complex technologies, new functional requirements, and safety requirements within “mobile” environment. Other elements taken into consideration include important aspects related to culture and customs in spatial design, which are linked with social perception of disability. The topic was analysed as part of a project: “New lines of mobility support products and accessibility of the environment for the elderly and disabled people”.

2 Methodology

The methodology accepted for research purposes included a combination of design ideas, as well as conclusions and theoretical research carried out according to the *research by design* method, i.e. *practice-based research*. *Research by design* is a recognized method which makes it possible to draw conclusions and expand knowledge in disciplines related to creative activities: architecture, industry design and art [1]. The designs presented herein constitute a creative input in spatial problem solution and play a role of an occasional experiment.

Research analysis stages:

- Developing a research thesis
- Thesis verification in the form of design simulation of the integrating kitchen:
 - analysis of design proposals for various types of layout: single row of furniture, two rows, U- or L-shaped, and kitchens with an island.
 - analysis of design proposals for mobile furniture modules.
 - analysis of kitchen's visual quality and style.
- Comparison of data related to the area of the room, layout of furniture, obtained accessibility, and degree of residents' integration, degree of modularisation and visual quality according to the *research by design* methodology.
- Conclusions.

3 Theses

Research and simulation related to the problems of kitchen space architectural arrangement and kitchen furniture designs shall verify three main assumptions:

- The use of mobile elements supported by gesture control system in kitchen makes it easier to undertake common, simultaneous activities by able-bodied people and people with disabilities; therefore it increases integration of the users of the space.
- Appropriate arrangement of kitchen space helps to optimize the number of jobs and functions that can be carried out by at least two persons.
- The presence of fixed and mobile modules in the furniture affects furniture forms and it can bring it closer to the visual effect of world's leading kitchen designs.

4 Concept Verification in the Form of Design Solutions Analysis

4.1 Spatial Arrangement Requirement

Concepts related to the flexible and multi-functional modelling of the space have been repeatedly brought up by the author both in theory [2] and design

realisations¹. This experience constitutes a basis for reflections and experiments related to dynamic changes of the functions of the space by using mobile elements in interiors. Kitchen realizations have also become a place where behaviours and habits inspired by the particular spatial solution could be observed.

Examples developed by the author, which constitute a starting point of the integrating kitchen design feature:

- an effective use of the space
- combination of several functions in one space
- the use of fixed and mobile partitions optimizing functional zones in the flat
- the use of contemporary style in harmony with modern architectural trends

Spatial conflicts occur in every kitchen used by more than one person and in the case of designing a place that will be simultaneously used by able-bodied and disabled persons conflicts are also caused by:

- differences in abilities and physical condition
- restricted or impossible access to kitchen elements, blocked access for walking people and wheelchair users.
- significant diversification of the ergonomic adjustment of furniture for able-bodied people and people with disabilities.

The purpose of the integrating kitchen design is to reduce the two latter conflicts, the access-related one and the ergonomic adjustment of furniture.

4.2 Integrating Kitchen – The Use of Fixed and Mobile Modules

Flexible integrating kitchen space, where the most important elements used in the food preparation process can be simultaneously used by an able-bodied person and a disabled one, comprises of fixed and mobile modules. Such solution benefits from lower electricity costs of actuators and their control [3]. It is important to situate individual modules in a way that facilitates simultaneous cooperation. Chapter 4.4 includes a comparison of mobile furniture modules designs, while Table 1. shows an example of an assessment of the accessibility of individual kitchen appliances.



¹ Author's design realisations: Interior design of a 110 m² flat at ul. Modra in Poznań, design of a 40 m² studio flat at ul Morawskiego in Poznań, design of an apartment at ul. Wielicka in Warsaw.

4.3 Design Simulations of Integrating Kitchen Solutions with Fixed and Mobile Modules, Types of Layout, and Legal Regulations

According to Polish technical and construction regulations [4] (as of 01.01.2012) the clear width of a kitchen in a multi-family building should equal at least 2.4 m in a flat and at least 1.8 m in a studio flat. These measurements determine the shape and type of kitchen arrangements and considerable restrictions when designing a kitchen for disabled people.

The arrangement of the integrating kitchen furniture in a studio flat with the minimum kitchen width is impossible in the case of closed rooms because after putting 60 cm-wide furniture there will be no room for the wheelchair to be turned around. However, a kitchenette opening into a hall can be used, which enables an arrangement of a kitchen with a single row of furniture. Also, extra lighting is not required for a studio flat, which worsens visual conditions in the case of a design prepared for an elderly person.

The minimum 2.4 m clear width of a kitchen in flats makes it possible to arrange an integrating kitchen with a single row of furniture or an L-shaped kitchen due to the fact that there must be room for a wheelchair to be turned around. Here, technical conditions also allow the kitchen to be joined with a living room. Based on the kitchen arrangement simulations it might be concluded that using an “open plan” and joining kitchen with the living room makes moving around the flat easier and provides more opportunities for verbal and visual communication.

The clear width of a kitchen that enables free arrangement using two rows of furniture, U- and L-shaped, must be 2.75 m. These layouts provide the greatest comfort when using a kitchen.

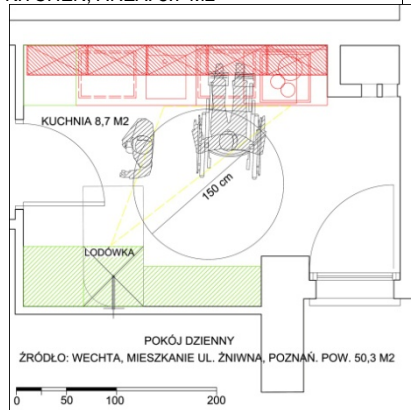
Design simulations of 10 kitchens were carried out for the purpose of the research, which illustrate:

- an arrangement of fixed and mobile modules,
- ability to ensure small distances between basic appliances (distance triangle: cooker, fridge, and sink)
- and make it possible to assess an accessibility of various functions by two people working simultaneously: an able-bodied person and a disabled one.

An example below shows one of the 10 simulations, and illustrates research principles. The arrangements were made based on real kitchens proposed by developers in single- and multi-family buildings in Poznan and Warsaw. Issues taken into consideration included various shape, kitchen areas, the location of gas connection and ventilation. In some cases kitchen was arranged in several ways. Diagram (Table 1.) prepared for each solution shows potential spatial conflicts in a sample kitchen with an assumption that it will be used by two persons: one with a disability and one able-bodied. The designs include an open-plan kitchen with a single row of furniture, a closed kitchen with a single row of furniture, a closed kitchen with two rows of furniture, an open-plan L-shaped kitchen, an L-shaped kitchenette, a closed L-shaped kitchen, a U-shaped kitchenette, a closed U-shaped kitchen, two kitchens with islands.

Symbol "N" indicates which actions cannot be simultaneously performed in the kitchen, "T" indicates ability to safely perform two actions, and "O" indicates small restrictions in activities.

Table 1. An example of the simulation of accessibility of six main functions in the integrating kitchen

INTEGRATING KITCHEN DESIGN NO 3 TWO ROWS OF FURNITURE, CLOSED KITCHEN, AREA: 8.7 M ² 	Able-bodied people		Product preparation	Heat treatment	Washing up	Access to the fridge	Access to the oven	Access to the storage zone
	People with disabilities							
Product preparation	Y	R	Y	Y	Y	Y	Y	Y
Heat treatment	Y	N	Y	Y	Y	Y	Y	Y
Washing up	Y	Y	N	Y	R	Y	Y	Y
Access to the oven	R	Y	Y	N	Y	Y	Y	Y
Access to the fridge	Y	Y	Y	R	N	R	R	R
Access to the main storage zone	Y	Y	Y	Y	R	N	N	N
Y-YES, N-NO, R-RESTRICTED ACCESS								

Based on an analogical analysis of 10 examples it can be concluded that:

- the largest amount of spatial conflicts occurs in L- and U-shaped kitchens and the smallest amount in kitchens with a single row or two rows of furniture.
- when it comes to ensuring shortest distances between basic kitchen appliances (the fridge, sink, and cooker triangle), U-and L-shaped kitchens come first. However, the scopes referred to in literature have been modified: distance from the fridge to the sink measures usually between 120 and 210 cm for normal kitchen, and in the integrating kitchen it should measure between 152 and 210 cm, distance from the sink to the cooker between 120 and 210 for normal kitchen, and in the integrating kitchen between 152 and 210, distance from the fridge to the cooker between 120 and 270 cm, and between 152 and 270 cm for the integrating kitchen.

To sum up, kitchens with two rows of furniture turned out to be the most useful for two reasons. They cause the lowest amount of spatial conflicts resulting from the simultaneous use by two people: a wheelchair bound disabled person and an able-bodied one. At the same time, the distances between basic kitchen appliances (the fridge, sink, and cooker triangle) remain small.

4.4 Solutions Used When Designing Mobile Modules of the Integrating Kitchen

A collection of kitchen furniture was created for the purpose of the integrating kitchen. Mobile modules designs feature kitchens that are comfortable to use both for wheelchair bound and able-bodied people.

4.4.1 A Set of Mobile Worktops

Worktops in integrating kitchen move upwards and can be regulated vertically by up to 20 cm. Individual modules can be moved independently which enables one person to work at a lowered module (person with disability) and the other at a raised worktop. Worktop position can be changed while working. Concave worktops facilitate drainage in one direction and prevent dripping to the sides.

Mobile worktops can contain an electric cooker or sink. The sink and cooker modules have been fitted with a top covering panel, which increases usable area of a given module. The worktop control mechanism can be moved manually; optionally, it can be powered electrically.

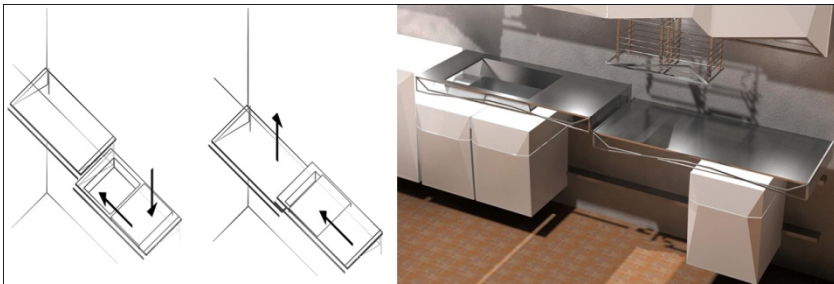


Fig. 1. Mobile kitchen worktops. Rendering by A. Bonenberg.

4.4.2 Mobile Lower Cabinets

Two sets of double drawers have been placed under the worktop level, and they move horizontally on a double rail fixed to the wall. By sliding the drawers apart it is possible to push the wheelchair under the worktop. While moving them together makes the kitchen look similar to the ones designed for able-bodied persons. Apart from two drawers (deep at the bottom and shallow on the top) each module is fitted with an additional pull-out worktop.

4.4.3 Upper Cabinets with a Pull-Out Internal Basket

The upper cabinets can be opened from a standing position - one of the front planes can be tilted, it can also be used from a seating position thanks to a drop openwork basket. The upper cabinet fronts have been designed as asymmetric, flat pyramids. The division into planes camouflages brackets of the openwork pull-down shelves.

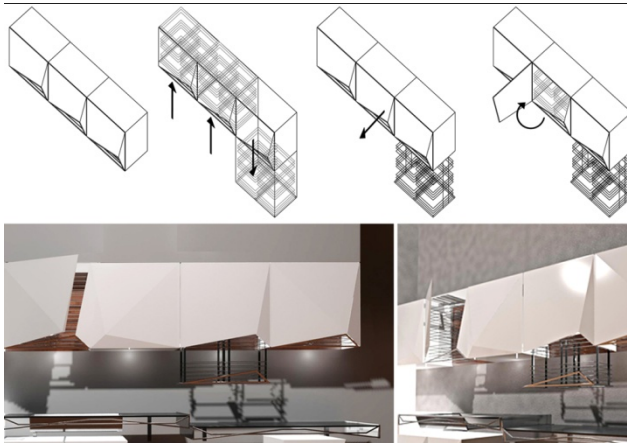


Fig. 2. Upper kitchen cabinets. Rendering by A. Bonenberg.

The capacity of one pull-down module is approx. 30 kg. Cabinet mechanism can be operated manually and electrically. Optionally, it can be controlled by gesture-based system.

4.4.4 Kitchen Cabinet

In a kitchen a major problem for wheel-bound people is the restricted accessibility to the storage space located in the upper parts of the room. The proposed solution enables all upper modules to be slid down to a comfortable position in the lower parts of the furniture in accordance with the diagram shown in Figure 2. It is possible to simultaneously use the furniture in sitting or standing positions. All storage space is accessible from the level of approx. 115 cm, mobile module capacity includes: 40 kg. Cubic volume of the cabinet is 1.25 m³ and useable capacity is 1.04 m³. It can be electrically powered.

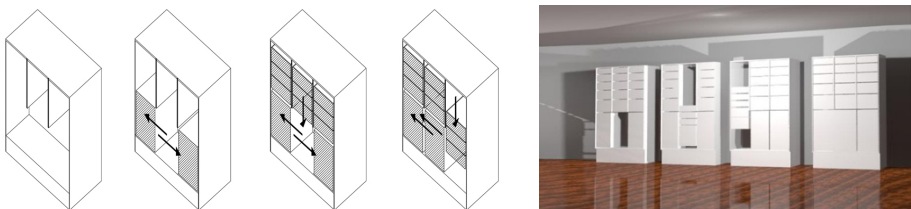


Fig. 3. Cabinet operation diagram. Rendering by A. Bonenberg.

4.4.5 Cabinet for Household Appliances with a Turn-Around Top

The problem related to the limited accessibility of upper storage space can also be solved by fitting a top above a piece of furniture that can be accessed by a wheelchair bound person. The idea of the top is for its body to revolve around an axle fitted to the wall. It can be turned by 90°. After placing it at a right angle to the wall an openwork

basket for crockery and products storage can be pulled down. The advantage of the top is that household appliances that cannot be moved can be placed in the lower piece of furniture: a cooker, microwave oven, under-counter fridge, and dishwasher. Two such appliances can be fitted into the cabinet. The maximum pull-out module capacity is: 25 kg, cabinet cubic volume: 1.7 m³, and it can be electrically powered.

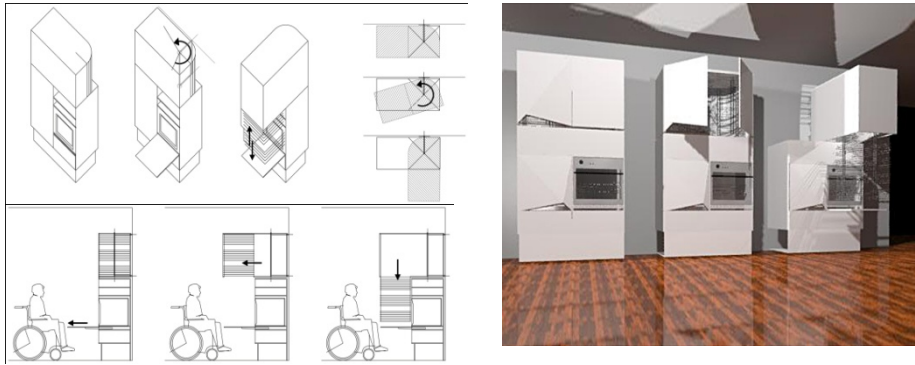


Fig. 4. The rotary top cross-section; lower cabinet contains an oven. Rendering by A. Bonenberg.

4.5 Visual and Compositional Qualities, and Style of Furniture Based on an Example of the *Integrating Kitchen* by a bonenberg

Research indicates that cultural aspect is very important when it comes to preferences related to the composition of a kitchen for disabled people [5]. Although the style and colours of kitchen furniture depend on individual preferences of a customer, when designing furniture for disabled people one basic preference can be observed: minimizing obvious compositional differences between kitchens designed for able-bodied and disabled people. Thus, either traditional or contemporary styles can be applied, but it is important to minimize the visibility of features which indicate that the space is used by disabled people. A particularly visible characteristic of a kitchen designed for disabled people is void space under the worktop which enables the wheelchair to be moved freely. In the *integrating kitchen* the “void space effect” is reduced to the minimum due to the use of under-counter mobile cabinets which can be moved horizontally. And although this solution creates a gap that enables a person to work at the worktop, this gap is significantly smaller than in other known solutions.

In the *integrating kitchen* design the author followed contemporary trends in architecture and interior design. A priority was to build kitchen furniture in a style that can be successfully used in closed rooms and as an addition to the living room decor (an open-plan kitchen) which results from the research presented in chapter 4.3. Characteristic forms of facets proposed in the design are on the one hand present in the mainstream structural solutions of contemporary architecture, and on the other hand they are used here to cover and camouflage functions typical for solutions designed for disabled people. Systems used to open cabinets, and brackets which enable worktops to be moved are treated as an ornament of the front part of the worktop.

The appearance of kitchen furniture is also important when selling a property and it can have an impact on the transaction - typical kitchens designed only for people with disabilities are seen by a new buyer as having little use. It must be emphasised that the integrating kitchen can be used in many different ways. The group of users can include people who want to perfectly adjust worktop height to their own height, so it also helps to optimize working environment for able-bodied people.

5 Summary: Comparison of Interrelations between Kitchen Types, Obtained Accessibility of Functions, Degree of Residents' Integration, Presence of Mobile Furniture Modules and Visual Quality

Table 1. Comparison of interrelations between kitchen types, obtained accessibility of functions, degree of residents' integration, presence of mobile furniture modules and visual quality

Kitchen type		Vicinity and accessibility of three main functions ²	Degree of residents' integration	Presence of mobile modules in the furniture	Compositional consistency ³
1.	Kitchen with a single row of furniture, open-plan, 8.7 m ²	1	80%	80%	5
2.	Kitchen with a single row of furniture, closed, 6.7 m ²	1	80%	80%	5
3.	Kitchen with two rows of furniture, closed, 8.7 m ²	3	86%	60%	4
4.	Kitchen with two rows of furniture, closed	3	86%	60%	5
5.	L-shaped, open-plan kitchen, 8.7 m ²	4	73%	66%	4
6.	L-shaped kitchenette, 7.9 m ²	5	75%	75%	4
7.	U-shaped kitchen, open-plan	4	70%	61%	3
8.	U-shaped kitchen, closed	5	73%	54%	3
9.	Kitchen with an island	5	72%	62%	5
10.	Kitchen with an island	4	78%	64%	5

Based on the analysed kitchen designs and the above comparison it is clear that the presence of mobile modules makes simultaneous work possible which enhances residents' integration. Accessibility of individual functions depends mainly on the layout of the kitchen; compositional consistency seems to be unrelated to the above factors.

² In order to assess vicinity and accessibility of three main functions, the distances between basic appliances (triangle: cooker, fridge, and sink) has been taken under consideration.

³ Evaluation based on 3D model simulations expert assessment.

6 Conclusions

Based on the prepared arrangements of responsive spaces in ten integrating kitchens and the presented five furniture solutions with gesture control system, it can be concluded that:

- Positive assessment of the degree of residents' integration depends on the useable area of the kitchen and type of layout. Layout helps to optimise the amount of work and functions that can be carried out in there.
- From the perspective of collision-free functioning, kitchens with two rows of furniture turned out to be most useful. The L- and U-shaped layouts are useful only if kitchen area exceeds 9 m². The use of mobile elements supported by gesture control system in kitchen makes it easier and quicker to undertake common, simultaneous activities by able-bodied people and people with disabilities; therefore it increases integration of the users of the space.
- Visual and compositional qualities and style of the furniture are important assets of the *integrating kitchen* design which takes into consideration the cultural aspect related to disability. Furniture forms are close to the visual effect of world's leading kitchen designs.

References

1. Büchler, D., Biggs, M., Perrone, R.: Academic Research in areas of Design Practice w International Conference on Design Research, Brasil, Rio de Janeiro (2010), http://www.academia.edu/948665/Academic_Research_in_areas_of_Design_Practice
2. Bonenberg, A.: Media, Przestrzeń, Architektura, Transformacje przestrzeni społeczeństwa informacyjnego, Wyd. Wydział Architektury Politechniki Poznańskiej, Poznań (2013)
3. Branowski, B., Rychlik, M., Sydor, M., Zabłocki, M.: 3D graphic database containing ergonomics data used when assessing virtual designs /kitchen adaptations for disabled people, "Wicnik" National University of Leopolis Polytechnic. Printing House of Leopolis Polytechnic (2011)
4. Wąchocki, R.: Przepisy Techniczno-budowlane dla budynków, ujednolicone teksty rozporządzeń, Polcen, Warszawa, p. 52, s.93 and 94 (2012)
5. Ko, Y., Kudo, T.: Development of Kitchen Models for Wheelchair Users – Focused on the Development and Evaluation of a System Kitchen Model Chich Reflects Conditions of Korea and Universal Design Concepts, http://www.idemployee.id.tue.nl/g.w.m.rauterberg/conferences/cd_donotopen/adc/final_paper/031.pdf (access February 10, 2013)